Ultra-Scale Tracking in Low-Resolution Image Sequences

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Vehicle tracking is a key technology for exploiting persistent surveillance. The technology to track thousands of vehicles over large, cluttered regions has the potential to provide the government with a fundamentally new intelligence source.

Project Goals

The project goal is to provide an advanced vehicle tracking capability for large (> 1 km x 1 km), long (> a few minutes), low resolution (~0.5 m/pixel), and low frame rate (~2 Hz) persistent surveillance image sequences, as well as a means to evaluate the performance of the capability. This capability was tested and documented on several relevant datasets. Other useful products include track visualization, track-file export capabilities (*e.g.*, to KML (Google Earth) and to a spatial database for further exploitation) and rapid generation of vehicle tracking ground-truth from large datasets.

Relevance to LLNL Mission

Prior to this year, LLNL did not have a capability to generate large-scale vehicle tracking information from remotely sensed video. Programs that directly benefit from this capability include NNSA NA-22 nonproliferation programs (*e.g.*, ICue), DoD-related programs (*e.g.*, Persistics), and other USG programs (*e.g.*, STED).

This project also directly advances the Engineering Systems for Knowledge and Inference (ESKI) Roadmap. The application areas of "detection and monitoring of WMD proliferation" and "sensor fusion for pattern discovery and inference" include traffic monitoring over regions that range in size from facilities to cities to countries, which then feed into multisource event prediction, pattern discovery, and activity models. It is difficult, if not impossible, to find the anomalous behavior of a vehicle without tracking a large number of vehicles to learn the normal patterns of behavior.

FY2008 Accomplishments and Results

We began this project with existing basic experimental interface definition language (IDL) tracking codes and significantly extended our capabilities to handle large and long datasets. We can now track all vehicles in a dataset with 4000 x 4000 pixels (at 0.5 m/pixel) by 1000 frames, possessing over 1500 movers/frame in roughly 45 min. At the start of the project, tracking on such a dataset was not feasible, and over halfway through the project, this would have taken many days to complete. For a shorter dataset with fewer objects, such as a set with 4000 x 4000 pixels by 200 frames with ~100 to 200 movers, it takes only a few minutes to complete the tracking. Our current method relies on the mover map, path dynamics, and image features to perform tracking. The benefit of using image features in addition to the mover map is that we can track vehicles not only when they move, but also when they stop. The algorithm performs very well when the vehicles are sufficiently separated and the

obscurations are small enough such that the vehicles keep a constant speed and direction under the obscuration.

We have also created IDL tools for the visualization of a single track of interest or multiple tracks in large datasets. The tracks can optionally be exported to kml or xml for further visualization or exploitation. An example of tracks detected in downtown San Diego overlaid on Google Earth is shown in the figure.

Related References

1. Collins, R. T., *et al.*, "A System for Video Surveillance and Monitoring," *VSAM Final Report*, Carnegie Mellon University, 2000. http://www.cs.cmu.edu/~vsam/research.html

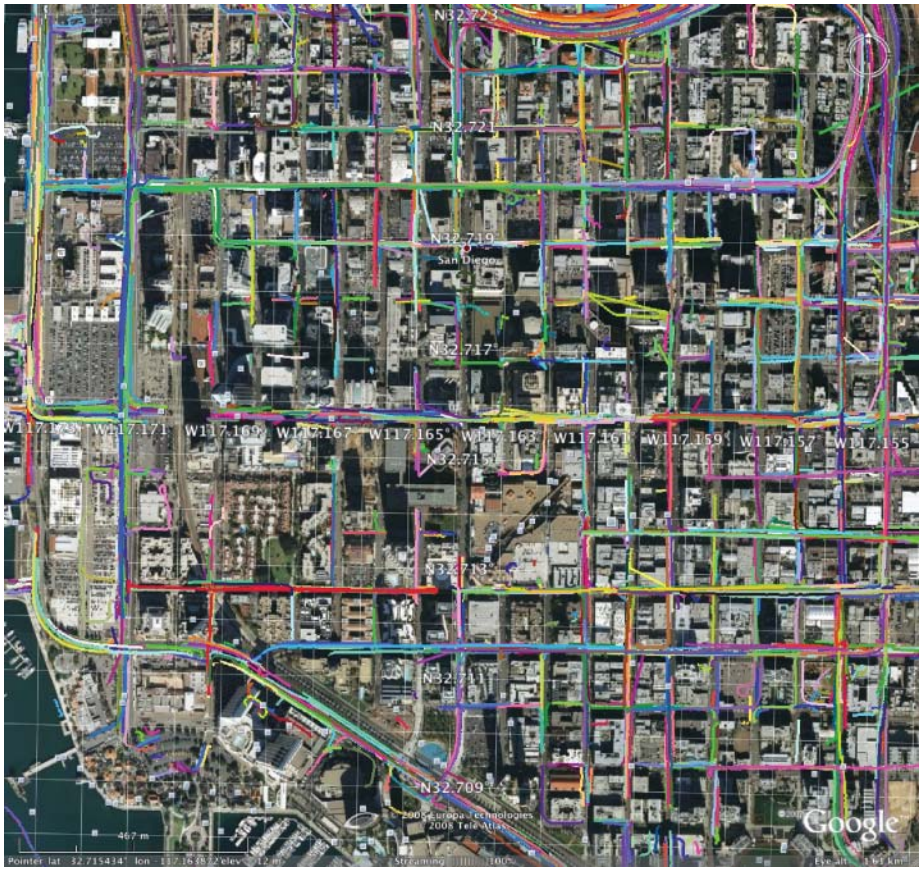
2. Lipton, A. J., H. Fujiyoshi, and R. S. Patil, "Moving Target Classification and Tracking from Real-Time Video," *WACV '98. Proceedings, 4th IEEE workshop on Applications of Computer Vision*, pp. 8–14, 1998.

3. Bell, W., P. Felzenszwalb, and D. Huttenlocher, "Detection and Long Term Tracking of Moving Objects in Aerial Video," *Technical Report, Computer Science*, Cornell, March 1999. http://www.cs.cornell.edu/vision/wbell/identtracker/

4. Baldini, G., *et al.*, "A simple and Robust Method for Moving Target Tracking," SPPRA, 2002.

FY2009 Proposed Work

Most clearly evident in the figure is the complexity of data at this scale. Since we would like to reliably and accurately evaluate how well the tracker performed, this leads us to the proposed FY2009 work of implementing a computer-aided track generation tool with minimal human intervention to establish ground-truth tracks. Using this ground-truthing tool we will be able to carry out repeatable experiments to assess performance of the tracker. It also facilitates important programmatic work to perform tracking assessment studies.



Detected tracks from 200 frames (100 s) of 2-Hz video overlaid on Google Earth.